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CLAIMS

[Claim(s)]
[Claim 1] It is the optical coupling machine which carries out incidence of the guided wave light which carried out outgoing radiation from the 1st optical waveguide to the 2nd optical waveguide. guided wave light is spread -- making -- the cross section of an end -- the spot size of said 1st optical waveguide -- substantial -- etc. -- the cross section of the other end to spread -- the spot size of said 2nd optical waveguide -- substantial -- etc. -- it spreads -- so that it may become The optical coupling machine with which the cross section is characterized by what it has the core which is changing continuously for along the propagation direction of light.
[Claim 2] The refractive index of said core is an optical coupling machine according to claim 1 characterized by what is being continuously changed along the propagation direction of light.
[Claim 3] Said core is an optical coupling machine according to claim 1 or 2 characterized by what is bent and formed so that it may exist in the range whose angle of the direction of outgoing radiation of the guided wave light from said 1st waveguide and the direction of incidence of the guided wave light to said 2nd waveguide to make is 0 - 180 degrees.
[Claim 4] Said core is an optical coupling machine given in claim 1 characterized by what was formed when laser was irradiated by the amorphous matter thru/or any 1 term of 3.
[Claim 5] The cross section and the refractive index of said core are an optical coupling machine given in claim 1 characterized by what is being changed continuously thru/or any 1 term of 4, when at least one of the amount of energy of the laser irradiated by the amorphous matter, the magnitude of a condensing point, the count of an exposure, and the passing speed of a condensing point changes.
[Claim 6] said core be an optical coupling machine given in claim 1 characterize by the thing it have turn at as it be in the range whose angle of the direction of outgoing radiation of the guided wave light from said 1st waveguide and the direction of incidence of the guided wave light to said 2nd waveguide to make be 0 - 180 degrees thru/or any 1 term of 5 , when an amorphous matter and the condensing point of the laser irradiated by the amorphous matter be displace relatively .
[Claim 7] The bottom clad formation process which is the manufacture approach of an optical coupling machine of carrying out incidence of the guided wave light which carried out outgoing radiation from the 1st optical waveguide to the 2nd optical waveguide, and forms a bottom cladding layer, The upper clad formation process which forms an upper cladding layer on said bottom cladding layer, The refractive index of the locus part which irradiated laser and the condensing point of this laser moved to either [at least] said bottom cladding layer or said upper cladding layer is changed. the cross section of an end -- the spot size of said 1st optical waveguide -- substantial -- etc. -- the cross section of the other end to spread -- the spot size of said 2nd optical waveguide -- substantial -- etc. -- it spreads -- so that it may become The manufacture approach of an optical coupling machine that the cross section is characterized by having the core formation process which forms the core which is changing continuously along the propagation direction of light.
[Claim 8] Said core formation process is the manufacture approach of the optical coupling machine according to claim 7 characterized by what it has for the process to which either [at least] the cross

section of said core or a refractive index is changed continuously by changing at least one of the amount of energy of said laser, the magnitude of a condensing point, the count of an exposure, and the passing speed of a condensing point.
[Claim 9] Said core formation process by making the condensing point of said laser displaced relatively to said bottom cladding layer and said upper cladding layer The manufacture approach of the optical coupling machine according to claim 7 or 8 characterized by what it has the process which bends a core for so that it may exist in the range whose angle of the direction of outgoing radiation of the guided wave light from said 1st waveguide and the direction of incidence of the guided wave light to said 2nd waveguide to make is 0 - 180 degrees.
[Claim 10] It is the manufacturing installation which manufactures the optical coupling machine which carries out incidence of the guided wave light which carried out outgoing radiation from the 1st optical waveguide to the 2nd optical waveguide. Said optical coupling machine guided wave light is spread -- making -- the cross section of an end -- the spot size of said 1st optical waveguide -- substantial -- etc. -- the cross section of the other end to spread -- the spot size of said 2nd optical waveguide -- substantial -- etc. -- it spreads -- so that it may become The cross section is equipped with the core which is changing continuously along the propagation direction of light. Said manufacturing installation A laser generation means to generate the laser beam which irradiates the table which lays the ingredient which is the candidate for an exposure of a laser beam, and the ingredient currently laid on said table, The lens which condenses the laser beam generated by said laser generation means, a path change means to change the diameter of a condensing spot of the laser beam condensed with said lens, and the core means forming which the relative position of said ingredient and said lens is changed, and forms said core in this ingredient -- since -- the manufacturing installation characterized by being constituted.
[Claim 11] It is the manufacturing installation according to claim 10 characterized by what said lens is the liquid sealed by the thin film, and said path change means changes the diameter of a condensing spot of the laser beam generated by said laser generation means by changing the configuration of said lens for.

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DETAILED DESCRIPTION

[Detailed Description of the Invention]
[0001]
[Field of the Invention] About the manufacture approach of the optical coupling machine which combines the optical waveguides from which the spot size of guided wave light differs, and an optical coupling machine, and a manufacturing installation, especially, this invention combines optical waveguides by low loss, and relates to the manufacture approach of the optical coupling machine which can be manufactured by the easy approach, and an optical coupling machine, and a manufacturing installation.
[0002]
[Description of the Prior Art] Researches and developments of the optical controlling element for controlling the lightwave signal used by optic fiber communication etc. in recent years are done briskly. Especially the planar optical waveguide device constituted by the optical waveguide formed on the substrate attracts attention from the reasons of small, right mass-production nature, few loss, high control effectiveness, etc. the core to which a light corpuscle child's above photoconductive optical paths generally have a refractive index higher than a clad and a clad -- since -- it is formed. Moreover, propagation of light is controllable by changing the refractive index of a core or a clad.
[0003] The technique of manufacturing such optical waveguide is indicated by JP,63-23712,A, JP,1-96604,A, and JP,9-311237,A. In the technique currently indicated by JP,63-23712,A, the clad is formed with the quality of the material from which a refractive index changes with elevated temperatures. And after forming into a clad the core which has a refractive index higher than a clad, laser is irradiated at a clad and the refractive index of a clad is changed along the propagation direction of light with the heat of the laser.
[0004] In the technique currently indicated by JP,1-96604,A, the core is formed with the quality of the material from which a refractive index changes at high temperature. And after forming the core film on a substrate, laser is irradiated, the refractive index is changed to the core film, patterning is carried out by dry etching etc., and the core from which the refractive index is changing along the propagation direction of light is formed. If the technique currently indicated by JP,9-311237,A condenses a laser beam with a high peaking capacity value with a lens etc. and irradiates a glass ingredient, it will use that the refractive index of a condensing part rises. And a laser beam is condensed in a glass ingredient and the refractive index forms optical waveguide (core) different the surroundings in a glass ingredient by moving the condensing point.
[0005] The refractive index of a clad or a core can be changed with the above techniques, light can close and eye ** can be strengthened, so that the refractive-index difference of a core and a clad is large. If light closes and eye ** is strong, also with small bend radii, optical waveguide can draw light efficiently and can miniaturize optical waveguide. However, if the refractive-index difference of a core and a clad is enlarged with the size of a core fixed, propagation of many modes may be attained, and the property of optical waveguide may deteriorate. When many modes can be spread, specifically, the pulse width of the pulsed light which spread optical waveguide may spread, before incidence of the light is carried out

to optical waveguide. Therefore, in order to miniaturize optical waveguide, it is necessary to both carry out core size to if for the refractive-index difference of a core and a clad to be enlarged small. However, if core size is made small, the spot size of guided wave light will also become small, and joint loss with the optical fiber which has optical waveguide with a comparatively large spot size becomes large.
[0006] With the technique currently indicated by above-mentioned JP,63-23712,A, since the core is already formed into the clad, there is a problem that core size cannot be changed. Moreover, with the technique currently indicated by JP,1-96604,A and JP,9-311237,A, since changing the size of optical waveguide (core) is not taken into consideration, when the spot size of the guided wave light to combine differs, joint loss may become large like the above. The technique which combines the optical waveguides from which the spot size of guided wave light differs is indicated by JP,4-220609,A and JP,8-171020,A.
[0007] The parts of the already formed optical fiber are heated by laser, core size is expanded, and it enables it to couple directly the optical waveguides from which core size differs with the technique currently indicated by JP,4-220609,A. With the technique currently indicated by JP,8-171020,A, in order to combine the optical waveguides from which spot size differs, the width of face and the height of a core which are formed on a substrate are gradually changed by selective etching etc.
[0008]
[Problem(s) to be Solved by the Invention] Laser is irradiated, the core size is changed to the optical fiber already formed, and it enables it to couple directly the optical fiber with which core sizes differ with the technique currently indicated by JP,4-220609,A. Therefore, when that optical fiber is cut on the way after changing core sizes, such as an optical fiber, with this technique, laser must be irradiated once again and core size must be changed. That is, unless it is after determining the operating die length of an optical fiber etc., this technique cannot be applied, but there is a problem of being inconvenient.
[0009] With the technique currently indicated by JP,8-171020,A, in order to change the spot size of guided wave light, the width of face and the height of a core are gradually changed by etching etc. Thus, when changing core size gradually by etching, in order to change size in the direction perpendicular to a substrate, it is necessary to repeat local membrane formation and local etching, and there is a problem that a production process becomes complicated. Moreover, since patterning of the core is carried out by etching etc., there is a problem that a core can be formed only in the direction which met the substrate. Therefore, this invention aims at resisting the optical coupling machine which combines the optical waveguides from which the spot size of guided wave light differs by low joint loss. Moreover, this invention is an easy approach and aims at offering the manufacture approach of an optical coupling machine and manufacturing installation which improve productivity.
[0010]
[Means for Solving the Problem] In order to attain the above-mentioned purpose, the optical coupling machine concerning the 1st viewpoint of this invention It is the optical coupling machine which carries out incidence of the guided wave light which carried out outgoing radiation from the 1st optical waveguide to the 2nd optical waveguide. Guided wave light is made to spread, the cross section of an end is substantially [as the spot size of said 1st optical waveguide] equal, and the cross section is characterized by what it has the core which is changing continuously for along the propagation direction of light so that the cross section of the other end may become equal substantially with the spot size of said 2nd optical waveguide.
[0011] Since the cross section of the core which light spreads is changing continuously according to this invention, the optical waveguides from which the spot size of guided wave light differs are combinable by low joint loss. The refractive index of said core may be changing continuously along the propagation direction of light. It bends and said core may be formed so that it may exist in the range whose angle of the direction of outgoing radiation of the guided wave light from said 1st waveguide and the direction of incidence of the guided wave light to said 2nd waveguide to make is 0 - 180 degrees.
[0012] Said core may be formed when laser is irradiated by the amorphous matter. The cross section and the refractive index of said core may be changing continuously, when at least one of the amount of energy of the laser irradiated by the amorphous matter, the magnitude of a condensing point, the count

of an exposure, and the passing speed of a condensing point changes. When the amorphous matter and the condensing point of the laser irradiated by the amorphous matter are displaced relatively, as it is in the range whose angle of the direction of outgoing radiation of the guided wave light from said 1st waveguide and the direction of incidence of the guided wave light to said 2nd waveguide to make is 0 - 180 degrees, you may turn at said core.

[0013] The manufacture approach of the optical coupling machine concerning the 2nd viewpoint of this invention The bottom clad formation process which is the manufacture approach of an optical coupling machine of carrying out incidence of the guided wave light which carried out outgoing radiation from the 1st optical waveguide to the 2nd optical waveguide, and forms a bottom cladding layer, The upper clad formation process which forms an upper cladding layer on said bottom cladding layer, The refractive index of the locus part which irradiated laser and the condensing point of this laser moved to either [at least] said bottom cladding layer or said upper cladding layer is changed. the cross section of an end -- the spot size of said 1st optical waveguide -- substantial -- etc. -- the cross section of the other end to spread -- the spot size of said 2nd optical waveguide -- substantial -- etc. -- it spreads -- so that it may become The cross section is characterized by having the core formation process which forms the core which is changing continuously along the propagation direction of light.

[0014] Since the cross section of the core which light spreads is changed continuously according to this invention, the optical waveguides from which the spot size of guided wave light differs are combinable by low joint loss. Moreover, a core can be easily formed only by irradiating laser. Said core formation process may be equipped with the process to which either [at least] the cross section of said core or a refractive index is changed continuously by changing at least one of the amount of energy of said laser, the magnitude of a condensing point, the count of an exposure, and the passing speed of a condensing point.

[0015] By making the condensing point of said laser displaced relatively to said bottom cladding layer and said upper cladding layer, said core formation process may be equipped with the process which bends a core so that it may exist in the range whose angle of the direction of outgoing radiation of the guided wave light from said 1st waveguide and the direction of incidence of the guided wave light to said 2nd waveguide to make is 0 - 180 degrees.

[0016] The manufacturing installation of the optical coupling machine concerning the 3rd viewpoint of this invention It is the manufacturing installation which manufactures the optical coupling machine which carries out incidence of the guided wave light which carried out outgoing radiation from the 1st optical waveguide to the 2nd optical waveguide. Said optical coupling machine guided wave light is spread -- making -- the cross section of an end -- the spot size of said 1st optical waveguide -- substantial -- etc. -- the cross section of the other end to spread -- the spot size of said 2nd optical waveguide -- substantial -- etc. -- it spreads -- so that it may become The cross section is equipped with the core which is changing continuously along the propagation direction of light. Said manufacturing installation A laser generation means to generate the laser beam which irradiates the table which lays the ingredient which is the candidate for an exposure of a laser beam, and the ingredient currently laid on said table, The lens which condenses the laser beam generated by said laser generation means, a path change means to change the diameter of a condensing spot of the laser beam condensed with said lens, and the core means forming which the relative position of said ingredient and said lens is changed, and forms said core in this ingredient -- since -- it is characterized by being constituted.

[0017] Said lens is the liquid sealed by the thin film, and said path change means may change the diameter of a condensing spot of the laser beam generated by said laser generation means by changing the configuration of said lens.

[0018]
[Embodiment of the Invention] Next, the optical coupling machine concerning the gestalt of operation of the 1st of this invention and its manufacture approach are explained with reference to a drawing. The optical coupling machine concerning the gestalt of the 1st operation is formed between the 1st optical waveguide and the 2nd optical waveguide from which the spot size of guided wave light differs, as typically shown in drawing 1 . And from one optical waveguide, the optical waveguide of another side is

made to spread the light which carried out outgoing radiation, and an optical coupling machine carries out incidence.

[0019] Drawing 2 is the mimetic diagram showing the configuration of the optical coupling machine concerning the gestalt of the 1st operation. In addition, drawing 2 (a) is a sectional view at the time of cutting in respect of being perpendicular to the substrate of an optical coupling machine including the propagation shaft of the propagation path (optical waveguide) of light, and drawing 2 (b) is a sectional view at the time of cutting in respect of being parallel to the substrate of an optical coupling machine including the propagation shaft of optical waveguide. moreover, drawing 2 (c) -- the A-A' view Fig. of drawing 2 (b) -- it is -- drawing 2 (d) -- B-B' of drawing 2 (b) -- it is a view Fig. it is shown in drawing 2 -- as -- an optical coupling machine -- a substrate 11, the bottom cladding layer 12, the 1st core 13, the upper cladding layer 14, and the 2nd core 15 -- since -- it is constituted.

[0020] The substrate 11 is formed from silicon (Si). The bottom cladding layer 12 is formed on the substrate 11, and the material is glass with which the amorphous matter (germanium), for example, germanium, or titanium (Ti) was doped. If germanium and titanium are doped on glass, a laser beam can be irradiated and the refractive index can be changed so that it may mention later. Moreover, since silicon is used for a substrate 11, the electric field of guided wave light may be built over a substrate 11 depending on the propagating mode of guided wave light, and may produce the propagation loss of optical waveguide. Therefore, in order to reduce this propagation loss, the thickness of the bottom cladding layer 12 is set as extent which does not require the electric field of guided wave light for a substrate 11. As for the thickness of the bottom cladding layer 12, specifically, it is desirable that it is 10 micrometers or more.

[0021] The 1st core 13 is formed in the part on the bottom cladding layer 12 from the glass membrane which has a refractive index higher than the bottom cladding layer 12. As shown in drawing 1 , the same, for example, width of face, and the height of the size of the 1st core 13 are 3-6 micrometers as substantially as the spot size of the light which spreads one optical waveguide. In addition, high-concentration germanium (germanium) or titanium (Ti) is doped rather than the clad by the glass membrane which forms the 1st core 13 so that it may have a refractive index with the 1st core 13 higher than the bottom cladding layer 12. moreover, the end of the 1st core 13 -- the bottom cladding layer 12 -- it connects with the 2nd core 15 in the center mostly.

[0022] The upper cladding layer 14 is the amorphous film which has a refractive index lower than the 1st core 13, i.e., the same quality of the material as the bottom cladding layer 12, and it is formed so that the 1st core 13 and 2nd core 15 may be covered.

[0023] From the bottom cladding layer 12 and the upper cladding layer 14, as the 2nd core 15 is mentioned later, it is formed, and it has a refractive index higher than the bottom cladding layer 12 and the upper cladding layer 14. However, the refractive index of the 2nd core 15 is small continuously as it is almost equal to the refractive index of the 1st core 13 and separates from the connection side 17 in respect of [17] connection with the 1st core 13. Moreover, the cross section of the 2nd core 15 is large continuously as it is almost equal to the cross section of the 1st core 13 and separates from the connection side 17 in respect of [17] connection with the 1st core 13. That is, as shown in drawing 1 , by the end, the cross section of a core becomes the same substantially with the spot size of one optical waveguide, and it is formed by the other end so that it may become the same substantially with the spot size of the optical waveguide of another side.

[0024] Next, the manufacture approach of the optical coupling machine which are the above configurations is explained. it is shown in introduction and drawing 3 (a) -- as -- a substrate 11 top -- chemical vapor deposition (CVD) -- the bottom cladding layer 12 is formed by law. In addition, as described above in this case, in order to reduce the propagation loss of optical waveguide, thickness of the bottom cladding layer 12 is set to 10 micrometers or more. next, the bottom cladding layer 12 top -- glass membrane with a refractive index higher than the bottom cladding layer 12 -- chemical vapor deposition (CVD) -- membranes are formed by law. And by the photolithography method and the etching method, as shown in drawing 3 (b), patterning of the above-mentioned glass membrane is carried out, and the 1st core 13 width of face and whose height are 3-6 micrometers is formed.

[0025] and the upper cladding layer 14 with a refractive index lower than the 1st core 13 after forming the 1st core 13 -- chemical vapor deposition (CVD) -- by law, as shown in drawing 3 (c), it forms on the bottom cladding layer 12 and the 1st core 13. In addition, in order to reduce the polarization dependency of optical waveguide, it is desirable to make equal the refractive index of the upper cladding layer 14 and the bottom cladding layer 12. Next, as shown in drawing 3 (d), the beam which condensed with the lens the laser beam 21 generated with the laser oscillation vessel etc. is irradiated at the bottom cladding layer 12 and the upper cladding layer 14, a refractive index is changed, and the 2nd core 15 which has a refractive index higher than the surroundings is formed.

[0026] In the exposure of this laser beam 21, laser radiation equipment as shown in drawing 4 is used, for example. this laser radiation equipment -- a table 31, the table support mechanical component 32, the laser oscillation machine 33, a lens 34, the lens support mechanical component 35, and a tube 36 -- since -- it is constituted. A table 31 lays the ingredient (the bottom cladding layer 12, the 1st core 13, and substrate 11 that had the upper cladding layer 14 formed) which irradiates laser, and is fixed. The table support mechanical component 32 moves a table 31, and changes the relative position of the ingredient on a table 31, and a lens 34.

[0027] The laser oscillation machine 33 generates the laser beam 21 for changing the refractive index of the bottom cladding layer 12 and the upper cladding layer 14, and forming a core (optical waveguide). A lens 34 consists of liquids sealed by the thin film, for example, and condenses the laser beam 21 from the laser oscillation machine 33. The lens support mechanical component 35 holds and moves a lens 34, and changes the relative position of the ingredient on a table 31, and a lens 34.

[0028] It connects with the liquid feeder which is not illustrated, and a tube 36 supplies a liquid to a lens 34, and transforms the form of a lens 34, and the diameter of a condensing spot of the laser beam 21 condensed with a lens 34 is changed. In addition, actuation of each part which constitutes the above-mentioned laser radiation equipment is controlled by control units, such as a computer, according to the pro crumb offered beforehand. For example, actuation of the above-mentioned table support mechanical component 32 and the lens support mechanical component 35 is controlled by the control unit etc. so that the 2nd core 15 is formed in the predetermined location in an ingredient. Moreover, generation of the laser beam 21 with the laser oscillation machine 33 and the liquid supply from a tube 36 are also controlled by the control unit etc. so that the diameter of a condensing spot of a laser beam 21 serves as predetermined magnitude.

[0029] In case a laser beam 21 is irradiated using the laser radiation equipment of the above configurations, the table support mechanical component 32 and the lens support mechanical component 35 adjust first so that the location of the condensing spot (condensing point) 22 of a laser beam 21 may become near the end face (connection side 17) of the 1st core 13. Then, at least one of the bottom cladding layer 12 and the upper cladding layer 14, and laser oscillation machines and lenses 34 is moved by the table support mechanical component 32 and the lens support mechanical component 35. That is, the condensing spot 22 is made displaced relatively to the bottom cladding layer 12 and the upper cladding layer 14. By this, a refractive index changes in the locus part (a part of bottom cladding layer 12 and upper cladding layer 14) of the condensing spot 22, and it becomes the 2nd core 15 which has a refractive index higher than the surroundings.

[0030] Moreover, the liquid supply from a tube 36 is controlled, the form of a lens 34 is changed to migration and coincidence of the condensing spot 22, and the diameter of a condensing spot is continuously changed to them. If it does in this way, as shown in drawing 5 (a) and (b), the cross section (core size) of the 2nd core 15 can be continuously changed with change of the diameter of a condensing spot. If the diameter of a condensing spot is enlarged, specifically, core size will become large. Therefore, it can become large continuously as the cross section of the 2nd core 15 is almost equal to the cross section of the 1st core 13 in respect of [17] connection with the 1st core 13 and separates from the connection side 17 in this case.

[0031] In addition, as a laser beam 21, laser with pulse width 150fs oscillated from 2OTi:aluminum3 laser of argon laser excitation, the repeat frequency of 200kHz, a wavelength [of 800nm], and an average output of about 600mW is used, for example. And it sets up so that the peak power reinforcement in the condensing spot 22 may become two or more 105 W/cm. By changing the cross section of the 2nd core 15 as mentioned above, the joint loss at the time of combining the optical coupling from which the spot size of guided wave light differs can be reduced.

[0032] Moreover, in case the condensing spot 22 is made displaced relatively to the bottom cladding layer 12 and the upper cladding layer 14 as described above, this passing speed is continuously changed by the table support mechanical component 32 and the lens support mechanical component 35. If it does in this way, as shown in drawing 6 (a) and (c), the refractive index of the 2nd core 15 can be changed continuously. If passing speed to the cladding layer of the condensing spot 22 is enlarged, specifically, the refractive index of the 2nd core 15 will become small. Therefore, it can become small continuously as the refractive index of the 2nd core 15 is almost equal to the refractive index of the 1st core 13 in respect of [17] connection with the 1st core 13 and separates from the connection side 17 in this case. Thus, since a refractive index will become small as the cross section becomes large if both the cross section of the 2nd core 15 and a refractive index are changed, propagation only of a certain specific mode can be attained, and it can raise the property of optical waveguide.

[0033] The optical coupling machine shown in drawing 2 above is completed. As shown above, the 2nd cross section and refractive index of a core 15 can be simply changed continuously only by changing the diameter of a condensing spot and passing speed of a laser beam 21. Therefore, core sizes differ, namely, the optical waveguides from which the spot size of guided wave light differs can be combined by low joint loss.

[0034] Moreover, generally the approach of irradiating a laser beam and forming optical waveguide into glass has a slow formation rate. However, since modification of spot size forms only a required part with laser among the cores which are optical waveguide and the other part is formed by the photolithography method for excelling in productivity as described above, productivity can be improved rather than the case where all optical waveguides are formed by laser.

[0035] Next, the optical coupling machine concerning the gestalt of operation of the 2nd of this invention and its manufacture approach are explained with reference to a drawing. The optical coupling machine concerning the gestalt of the 2nd operation is formed like the gestalt of the 1st operation between the 1st optical waveguide and the 2nd optical waveguide from which the spot size of guided wave light differs, and makes the optical waveguide of another side spread the light which carried out outgoing radiation from one optical waveguide. Moreover, in addition to the configuration of the optical coupling machine shown with the gestalt of the 1st operation, the optical coupling machine concerning the gestalt of the 2nd operation has the composition that the core bent on the way, as shown below.

[0036] Drawing 7 is the mimetic diagram showing the configuration of the optical coupling machine concerning the gestalt of the 2nd operation. In addition, drawing 7 (a) is a sectional view at the time of cutting in respect of being perpendicular to the substrate of an optical coupling machine including the propagation shaft of the propagation path (optical waveguide) of light, and drawing 7 (b) is a sectional view at the time of cutting in respect of being parallel to the substrate of an optical coupling machine. Moreover, drawing 7 (c) is the C-C' view Fig. of drawing 7 (b).

[0037] this optical coupling machine -- a substrate 11, the bottom cladding layer 12, the 1st core 13, the upper cladding layer 14, and the 2nd core 16 -- since -- it is constituted and is the almost same configuration as the photosynthesis machine shown with the gestalt of the 1st operation. However, the optical waveguide formed from the 1st core 13 and 2nd core 16 has bent in respect of [17] those connection. That is, to the 1st core 13 being formed in parallel with the front face of a substrate 11, the 2nd core 16 is formed so that it may have a certain include angle to the front face of a substrate 11.

[0038] Next, the manufacture approach of the optical coupling machine which are the above configurations is explained. It is the same as that of the gestalt of the 1st operation till the place which forms the bottom cladding layer 12 on introduction and a substrate 11, forms the 1st core 13 on the bottom cladding layer 12, and forms the upper cladding layer 14.

[0039] The condensing spot 22 is made displaced relatively to the bottom cladding layer 12 and the upper cladding layer 14 after formation of the upper cladding layer 14, using the laser radiation equipment shown in drawing 4 like the gestalt of the 1st operation, and changing the diameter of a condensing spot continuously, in order to form the 2nd core 16. Thereby, the locus part (a part of upper cladding layer 14) of the condensing spot 22 has a refractive index higher than a perimeter, and can form the 2nd core 16 from which the cross section changed continuously. Moreover, in case the condensing spot 22 is moved, by the table support mechanical component 32 and the lens support mechanical component 35, at least one of a lens 34, and the bottom cladding layers 12 and the upper cladding layers 14 is moved, and the distance of a lens 34 and an optical coupling machine front face is changed. The 1st core 13 and 2nd core 16 are connected in the bent form by this. In addition, the pulse width of the laser beam 21 to be used, output power, etc. are substantially [as the gestalt of the 1st operation] the same.

[0040] As furthermore described above, the refractive index of the 2nd core 16 can be changed with the passing speed of the condensing spot 22. In order to use this, the passing speed of the condensing spot 22 to the bottom cladding layer 12 and the upper cladding layer 14 is changed by the table support mechanical component 32 and the lens support mechanical component 35 of laser radiation equipment. It is made for the refractive-index difference of a core and a clad to become large by this. If it does in this way, light can close, eye ** can be strengthened, it can make it sudden to bend [core / 1st core 13 and / 16 / 2nd], and an optical coupling machine can be miniaturized.

[0041] An optical coupling machine is completed for the light shown in drawing 7 as mentioned above. As shown above, the optical waveguide which consists of the 1st core 13 and 2nd core 16 simply can be bent only by controlling the path and migration of the condensing spot 22. Moreover, the angle which the direction of outgoing radiation of the light from one optical waveguide and the direction of incidence of the light to the optical waveguide of another side make can set it as all the include angles of 0 - 180 degrees by changing how bending a core variously. Therefore, optical waveguides can be efficiently combined at various include angles by the small propagation loss, and the mounting cost of an optical device which has optical waveguide can be reduced.

[0042] Moreover, also in the gestalt of the 2nd operation, since modification of spot size forms only a required part with laser among the cores which are optical waveguide and the other part is formed by the photolithography method for excelling in productivity as described above, productivity can be improved rather than the case where all optical waveguides are formed by laser.

[0043] In addition, you may make it change by the approach except changing passing speed [as opposed to the clad of the diameter of a condensing spot, or the condensing spot 22 for the core size shown with the gestalt of the 1st and the 2nd operation, or the refractive index of a core]. For example, a diaphragm etc. may be established between the laser oscillation machine 33 of laser radiation equipment, and a lens 34, and the exposure power (the amount of energy) of a laser beam 21 may be changed. If the exposure power of a laser beam 21 is changed, as shown in drawing 5 (a) and (b), core size of the 2nd core 15 can be enlarged with the increment in exposure power. Moreover, the refractive index of a core may be changed by controlling the laser oscillation machine 33 and changing the count of an exposure of a laser beam 21. If the count of an exposure of a laser beam 21 is changed, as shown in drawing 6 (b) and (c), a refractive index can be reduced with reduction of the count of an exposure.

[0044] Furthermore, in order to change core size, the count of an exposure of the passing speed of the condensing spot 22 or a laser beam 21 may be changed. Moreover, in order to change the refractive index of a core, the exposure power of a laser beam 21 may be changed. Moreover, the above-mentioned approaches (passing speed of exposure power change of a laser beam 21, the diameter change of a condensing spot, and a condensing spot, count change of an exposure of a laser beam 21, etc.) may be combined and used. Moreover, as a means to change the path of the condensing spot 22 shown with the gestalt of the 1st and the 2nd operation, instead of changing the configuration of a lens 34, two or more lenses may be combined like the zoom lens of a single-lens reflex camera, and the distance between them may be changed.

[0045] Moreover, the 1st core 13 shown with the gestalt of the 2nd operation and the 2nd core 16 can also connect the 1st core 13 and 2nd core 16 by the smooth curve by controlling migration of the above-mentioned condensing spot 22, although it connects in the bent form. Thus, if optical waveguide is formed smoothly, a propagation loss can be reduced more.

[0046] The substrate 11 shown with the gestalt of the 1st and the 2nd operation, the bottom cladding layer 12, and the upper cladding layer 14 of either oxide glass, nitride glass, halogenation glass, sulfide glass and chalcogenide glass may be good, and may be those mixture. In addition, since it is hard to be influenced by the electric field of guided wave light when a substrate 11 is quartz (SiO2) glass etc., the bottom cladding layer 12 is omissible. Moreover, if a substrate 11 is used as a transparence substrate like a glass substrate, the laser beam 21 of ** which forms the 2nd core 15 as described above can be irradiated from a substrate 11 side.
[0047] moreover, the bottom cladding layer 12 shown with the gestalt of the 1st and the 2nd operation, the glass membrane used as the 1st core 13, and the upper cladding layer 14 -- chemical vapor deposition (CVD) -- law -- it may be formed by the approach of an except. for example, flame deposition (FHD) -- any of law, a spatter, and a spin coat method -- even when -- it may be good and such suitable combination is sufficient.
[0048]
[Effect of the Invention] Since the cross section of the core which light spreads is changing with this inventions continuously so that clearly from the above explanation, the optical waveguides from which the spot size of guided wave light differs are combinable by low joint loss. Moreover, a core can be easily formed only by irradiating laser. Furthermore, by moving the condensing point of laser, a core can be bent so that it may exist in the range whose angle of the direction of outgoing radiation of the guided wave light from the 1st waveguide and the direction of incidence of the guided wave light to the 2nd waveguide to make is 0 - 180 degrees. By this, an optical coupling machine can be miniaturized and the mounting cost of an optical device which has optical waveguide can be reduced.

[Translation done.]

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TECHNICAL FIELD

[Field of the Invention] About the manufacture approach of the optical coupling machine which combines the optical waveguides from which the spot size of guided wave light differs, and an optical coupling machine, and a manufacturing installation, especially, this invention combines optical waveguides by low loss, and relates to the manufacture approach of the optical coupling machine which can be manufactured by the easy approach, and an optical coupling machine, and a manufacturing installation.

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PRIOR ART

[Description of the Prior Art] Researches and developments of the optical controlling element for controlling the lightwave signal used by optic fiber communication etc. in recent years are done briskly. Especially the planar optical waveguide device constituted by the optical waveguide formed on the substrate attracts attention from the reasons of small, right mass-production nature, few loss, high control effectiveness, etc. the core to which a light corpuscle child's above photoconductive optical paths generally have a refractive index higher than a clad and a clad -- since -- it is formed. Moreover, propagation of light is controllable by changing the refractive index of a core or a clad.
[0003] The technique of manufacturing such optical waveguide is indicated by JP,63-23712,A, JP,1-96604,A, and JP,9-311237,A. In the technique currently indicated by JP,63-23712,A, the clad is formed with the quality of the material from which a refractive index changes with elevated temperatures. And after forming into a clad the core which has a refractive index higher than a clad, laser is irradiated at a clad and the refractive index of a clad is changed along the propagation direction of light with the heat of the laser.
[0004] In the technique currently indicated by JP,1-96604,A, the core is formed with the quality of the material from which a refractive index changes at high temperature. And after forming the core film on a substrate, laser is irradiated, the refractive index is changed to the core film, patterning is carried out by dry etching etc., and the core from which the refractive index is changing along the propagation direction of light is formed. If the technique currently indicated by JP,9-311237,A condenses a laser beam with a high peaking capacity value with a lens etc. and irradiates a glass ingredient, it will use that the refractive index of a condensing part rises. And a laser beam is condensed in a glass ingredient and the refractive index forms optical waveguide (core) different the surroundings in a glass ingredient by moving the condensing point.
[0005] The refractive index of a clad or a core can be changed with the above techniques, light can close and eye ** can be strengthened, so that the refractive-index difference of a core and a clad is large. If light closes and eye ** is strong, also with small bend radii, optical waveguide can draw light efficiently and can miniaturize optical waveguide. However, if the refractive-index difference of a core and a clad is enlarged with the size of a core fixed, propagation of many modes may be attained, and the property of optical waveguide may deteriorate. When many modes can be spread, specifically, the pulse width of the pulsed light which spread optical waveguide may spread, before incidence of the light is carried out to optical waveguide. Therefore, in order to miniaturize optical waveguide, it is necessary to both carry out core size to if for the refractive-index difference of a core and a clad to be enlarged small. However, if core size is made small, the spot size of guided wave light will also become small, and joint loss with the optical fiber which has optical waveguide with a comparatively large spot size becomes large.
[0006] With the technique currently indicated by above-mentioned JP,63-23712,A, since the core is already formed into the clad, there is a problem that core size cannot be changed. Moreover, with the technique currently indicated by JP,1-96604,A and JP,9-311237,A, since changing the size of optical waveguide (core) is not taken into consideration, when the spot size of the guided wave light to combine differs, joint loss may become large like the above. The technique which combines the optical

waveguides from which the spot size of guided wave light differs is indicated by JP,4-220609,A and JP,8-171020,A.

[0007] The parts of the already formed optical fiber are heated by laser, core size is expanded, and it enables it to couple directly the optical waveguides from which core size differs with the technique currently indicated by JP,4-220609,A. With the technique currently indicated by JP,8-171020,A, in order to combine the optical waveguides from which spot size differs, the width of face and the height of a core which are formed on a substrate are gradually changed by selective etching etc.

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EFFECT OF THE INVENTION

[Effect of the Invention] Since the cross section of the core which light spreads is changing with this inventions continuously so that clearly from the above explanation, the optical waveguides from which the spot size of guided wave light differs are combinable by low joint loss. Moreover, a core can be easily formed only by irradiating laser. Furthermore, by moving the condensing point of laser, a core can be bent so that it may exist in the range whose angle of the direction of outgoing radiation of the guided wave light from the 1st waveguide and the direction of incidence of the guided wave light to the 2nd waveguide to make is 0 - 180 degrees. By this, an optical coupling machine can be miniaturized and the mounting cost of an optical device which has optical waveguide can be reduced.

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TECHNICAL PROBLEM

[Problem(s) to be Solved by the Invention] Laser is irradiated, the core size is changed to the optical fiber already formed, and it enables it to couple directly the optical fiber with which core sizes differ with the technique currently indicated by JP,4-220609,A. Therefore, when that optical fiber is cut on the way after changing core sizes, such as an optical fiber, with this technique, laser must be irradiated once again and core size must be changed. That is, unless it is after determining the operating die length of an optical fiber etc., this technique cannot be applied, but there is a problem of being inconvenient.
[0009] With the technique currently indicated by JP,8-171020,A, in order to change the spot size of guided wave light, the width of face and the height of a core are gradually changed by etching etc. Thus, when changing core size gradually by etching, in order to change size in the direction perpendicular to a substrate, it is necessary to repeat local membrane formation and local etching, and there is a problem that a production process becomes complicated. Moreover, since patterning of the core is carried out by etching etc., there is a problem that a core can be formed only in the direction which met the substrate. Therefore, this invention aims at resisting the optical coupling machine which combines the optical waveguides from which the spot size of guided wave light differs by low joint loss. Moreover, this invention is an easy approach and aims at offering the manufacture approach of an optical coupling machine and manufacturing installation which improve productivity.

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MEANS

[Means for Solving the Problem] In order to attain the above-mentioned purpose, the optical coupling machine concerning the 1st viewpoint of this invention It is the optical coupling machine which carries out incidence of the guided wave light which carried out outgoing radiation from the 1st optical waveguide to the 2nd optical waveguide. Guided wave light is made to spread, the cross section of an end is substantially [as the spot size of said 1st optical waveguide] equal, and the cross section is characterized by what it has the core which is changing continuously for along the propagation direction of light so that the cross section of the other end may become equal substantially with the spot size of said 2nd optical waveguide.

[0011] Since the cross section of the core which light spreads is changing continuously according to this invention, the optical waveguides from which the spot size of guided wave light differs are combinable by low joint loss. The refractive index of said core may be changing continuously along the propagation direction of light. It bends and said core may be formed so that it may exist in the range whose angle of the direction of outgoing radiation of the guided wave light from said 1st waveguide and the direction of incidence of the guided wave light to said 2nd waveguide to make is 0 - 180 degrees.

[0012] Said core may be formed when laser is irradiated by the amorphous matter. The cross section and the refractive index of said core may be changing continuously, when at least one of the amount of energy of the laser irradiated by the amorphous matter, the magnitude of a condensing point, the count of an exposure, and the passing speed of a condensing point changes. When the amorphous matter and the condensing point of the laser irradiated by the amorphous matter are displaced relatively, as it is in the range whose angle of the direction of outgoing radiation of the guided wave light from said 1st waveguide and the direction of incidence of the guided wave light to said 2nd waveguide to make is 0 - 180 degrees, you may turn at said core.

[0013] The manufacture approach of the optical coupling machine concerning the 2nd viewpoint of this invention The bottom clad formation process which is the manufacture approach of an optical coupling machine of carrying out incidence of the guided wave light which carried out outgoing radiation from the 1st optical waveguide to the 2nd optical waveguide, and forms a bottom cladding layer, The upper clad formation process which forms an upper cladding layer on said bottom cladding layer, The refractive index of the locus part which irradiated laser and the condensing point of this laser moved to either [at least] said bottom cladding layer or said upper cladding layer is changed. the cross section of an end -- the spot size of said 1st optical waveguide -- substantial -- etc. -- the cross section of the other end to spread -- the spot size of said 2nd optical waveguide -- substantial -- etc. -- it spreads -- so that it may become The cross section is characterized by having the core formation process which forms the core which is changing continuously along the propagation direction of light.

[0014] Since the cross section of the core which light spreads is changed continuously according to this invention, the optical waveguides from which the spot size of guided wave light differs are combinable by low joint loss. Moreover, a core can be easily formed only by irradiating laser. Said core formation process may be equipped with the process to which either [at least] the cross section of said core or a refractive index is changed continuously by changing at least one of the amount of energy of said laser,

the magnitude of a condensing point, the count of an exposure, and the passing speed of a condensing point.
[0015] By making the condensing point of said laser displaced relatively to said bottom cladding layer and said upper cladding layer, said core formation process may be equipped with the process which bends a core so that it may exist in the range whose angle of the direction of outgoing radiation of the guided wave light from said 1st waveguide and the direction of incidence of the guided wave light to said 2nd waveguide to make is 0 - 180 degrees.
[0016] The manufacturing installation of the optical coupling machine concerning the 3rd viewpoint of this invention It is the manufacturing installation which manufactures the optical coupling machine which carries out incidence of the guided wave light which carried out outgoing radiation from the 1st optical waveguide to the 2nd optical waveguide. Said optical coupling machine guided wave light is spread -- making -- the cross section of an end -- the spot size of said 1st optical waveguide -- substantial -- etc. -- the cross section of the other end to spread -- the spot size of said 2nd optical waveguide -- substantial -- etc. -- it spreads -- so that it may become The cross section is equipped with the core which is changing continuously along the propagation direction of light. Said manufacturing installation A laser generation means to generate the laser beam which irradiates the table which lays the ingredient which is the candidate for an exposure of a laser beam, and the ingredient currently laid on said table, The lens which condenses the laser beam generated by said laser generation means, a path change means to change the diameter of a condensing spot of the laser beam condensed with said lens, and the core means forming which the relative position of said ingredient and said lens is changed, and forms said core in this ingredient -- since -- it is characterized by being constituted.
[0017] Said lens is the liquid sealed by the thin film, and said path change means may change the diameter of a condensing spot of the laser beam generated by said laser generation means by changing the configuration of said lens.
[0018]
[Embodiment of the Invention] Next, the optical coupling machine concerning the gestalt of operation of the 1st of this invention and its manufacture approach are explained with reference to a drawing. The optical coupling machine concerning the gestalt of the 1st operation is formed between the 1st optical waveguide and the 2nd optical waveguide from which the spot size of guided wave light differs, as typically shown in drawing 1 . And from one optical waveguide, the optical waveguide of another side is made to spread the light which carried out outgoing radiation, and an optical coupling machine carries out incidence.
[0019] Drawing 2 is the mimetic diagram showing the configuration of the optical coupling machine concerning the gestalt of the 1st operation. In addition, drawing 2 (a) is a sectional view at the time of cutting in respect of being perpendicular to the substrate of an optical coupling machine including the propagation shaft of the propagation path (optical waveguide) of light, and drawing 2 (b) is a sectional view at the time of cutting in respect of being parallel to the substrate of an optical coupling machine including the propagation shaft of optical waveguide. moreover, drawing 2 (c) -- the A-A' view Fig. of drawing 2 (b) -- it is -- drawing 2 (d) -- B-B' of drawing 2 (b) -- it is a view Fig. it is shown in drawing 2 -- as -- an optical coupling machine -- a substrate 11, the bottom cladding layer 12, the 1st core 13, the upper cladding layer 14, and the 2nd core 15 -- since -- it is constituted.
[0020] The substrate 11 is formed from silicon (Si). The bottom cladding layer 12 is formed on the substrate 11, and the material is glass with which the amorphous matter (germanium), for example, germanium, or titanium (Ti) was doped. If germanium and titanium are doped on glass, a laser beam can be irradiated and the refractive index can be changed so that it may mention later. Moreover, since silicon is used for a substrate 11, the electric field of guided wave light may be built over a substrate 11 depending on the propagating mode of guided wave light, and may produce the propagation loss of optical waveguide. Therefore, in order to reduce this propagation loss, the thickness of the bottom cladding layer 12 is set as extent which does not require the electric field of guided wave light for a substrate 11. As for the thickness of the bottom cladding layer 12, specifically, it is desirable that it is 10 micrometers or more.

[0021] The 1st core 13 is formed in the part on the bottom cladding layer 12 from the glass membrane which has a refractive index higher than the bottom cladding layer 12. As shown in drawing 1 , the same, for example, width of face, and the height of the size of the 1st core 13 are 3-6 micrometers as substantially as the spot size of the light which spreads one optical waveguide. In addition, high-concentration germanium (germanium) or titanium (Ti) is doped rather than the clad by the glass membrane which forms the 1st core 13 so that it may have a refractive index with the 1st core 13 higher than the bottom cladding layer 12. moreover, the end of the 1st core 13 -- the bottom cladding layer 12 -- it connects with the 2nd core 15 in the center mostly.

[0022] The upper cladding layer 14 is the amorphous film which has a refractive index lower than the 1st core 13, i.e., the same quality of the material as the bottom cladding layer 12, and it is formed so that the 1st core 13 and 2nd core 15 may be covered.

[0023] From the bottom cladding layer 12 and the upper cladding layer 14, as the 2nd core 15 is mentioned later, it is formed, and it has a refractive index higher than the bottom cladding layer 12 and the upper cladding layer 14. However, the refractive index of the 2nd core 15 is small continuously as it is almost equal to the refractive index of the 1st core 13 and separates from the connection side 17 in respect of [17] connection with the 1st core 13. Moreover, the cross section of the 2nd core 15 is large continuously as it is almost equal to the cross section of the 1st core 13 and separates from the connection side 17 in respect of [17] connection with the 1st core 13. That is, as shown in drawing 1 , by the end, the cross section of a core becomes the same substantially with the spot size of one optical waveguide, and it is formed by the other end so that it may become the same substantially with the spot size of the optical waveguide of another side.

[0024] Next, the manufacture approach of the optical coupling machine which are the above configurations is explained. it is shown in introduction and drawing 3 (a) -- as -- a substrate 11 top -- chemical vapor deposition (CVD) -- the bottom cladding layer 12 is formed by law. In addition, as described above in this case, in order to reduce the propagation loss of optical waveguide, thickness of the bottom cladding layer 12 is set to 10 micrometers or more. next, the bottom cladding layer 12 top -- glass membrane with a refractive index higher than the bottom cladding layer 12 -- chemical vapor deposition (CVD) -- membranes are formed by law. And by the photolithography method and the etching method, as shown in drawing 3 (b), patterning of the above-mentioned glass membrane is carried out, and the 1st core 13 width of face and whose height are 3-6 micrometers is formed.

[0025] and the upper cladding layer 14 with a refractive index lower than the 1st core 13 after forming the 1st core 13 -- chemical vapor deposition (CVD) -- by law, as shown in drawing 3 (c), it forms on the bottom cladding layer 12 and the 1st core 13. In addition, in order to reduce the polarization dependency of optical waveguide, it is desirable to make equal the refractive index of the upper cladding layer 14 and the bottom cladding layer 12. Next, as shown in drawing 3 (d), the beam which condensed with the lens the laser beam 21 generated with the laser oscillation vessel etc. is irradiated at the bottom cladding layer 12 and the upper cladding layer 14, a refractive index is changed, and the 2nd core 15 which has a refractive index higher than the surroundings is formed.

[0026] In the exposure of this laser beam 21, laser radiation equipment as shown in drawing 4 is used, for example. this laser radiation equipment -- a table 31, the table support mechanical component 32, the laser oscillation machine 33, a lens 34, the lens support mechanical component 35, and a tube 36 -- since -- it is constituted. A table 31 lays the ingredient (the bottom cladding layer 12, the 1st core 13, and substrate 11 that had the upper cladding layer 14 formed) which irradiates laser, and is fixed. The table support mechanical component 32 moves a table 31, and changes the relative position of the ingredient on a table 31, and a lens 34.

[0027] The laser oscillation machine 33 generates the laser beam 21 for changing the refractive index of the bottom cladding layer 12 and the upper cladding layer 14, and forming a core (optical waveguide). A lens 34 consists of liquids sealed by the thin film, for example, and condenses the laser beam 21 from the laser oscillation machine 33. The lens support mechanical component 35 holds and moves a lens 34, and changes the relative position of the ingredient on a table 31, and a lens 34.

[0028] It connects with the liquid feeder which is not illustrated, and a tube 36 supplies a liquid to a lens

34, and transforms the form of a lens 34, and the diameter of a condensing spot of the laser beam 21 condensed with a lens 34 is changed. In addition, actuation of each part which constitutes the above-mentioned laser radiation equipment is controlled by control units, such as a computer, according to the pro crumb offered beforehand. For example, actuation of the above-mentioned table support mechanical component 32 and the lens support mechanical component 35 is controlled by the control unit etc. so that the 2nd core 15 is formed in the predetermined location in an ingredient. Moreover, generation of the laser beam 21 with the laser oscillation machine 33 and the liquid supply from a tube 36 are also controlled by the control unit etc. so that the diameter of a condensing spot of a laser beam 21 serves as predetermined magnitude.

[0029] In case a laser beam 21 is irradiated using the laser radiation equipment of the above configurations, the table support mechanical component 32 and the lens support mechanical component 35 adjust first so that the location of the condensing spot (condensing point) 22 of a laser beam 21 may become near the end face (connection side 17) of the 1st core 13. Then, at least one of the bottom cladding layer 12 and the upper cladding layer 14, and laser oscillation machines and lenses 34 is moved by the table support mechanical component 32 and the lens support mechanical component 35. That is, the condensing spot 22 is made displaced relatively to the bottom cladding layer 12 and the upper cladding layer 14. By this, a refractive index changes in the locus part (a part of bottom cladding layer 12 and upper cladding layer 14) of the condensing spot 22, and it becomes the 2nd core 15 which has a refractive index higher than the surroundings.

[0030] Moreover, the liquid supply from a tube 36 is controlled, the form of a lens 34 is changed to migration and coincidence of the condensing spot 22, and the diameter of a condensing spot is continuously changed to them. If it does in this way, as shown in drawing 5 (a) and (b), the cross section (core size) of the 2nd core 15 can be continuously changed with change of the diameter of a condensing spot. If the diameter of a condensing spot is enlarged, specifically, core size will become large. Therefore, it can become large continuously as the cross section of the 2nd core 15 is almost equal to the cross section of the 1st core 13 in respect of [17] connection with the 1st core 13 and separates from the connection side 17 in this case.

[0031] In addition, as a laser beam 21, laser with pulse width 150fs oscillated from 2OTi:aluminum3 laser of argon laser excitation, the repeat frequency of 200kHz, a wavelength [of 800nm], and an average output of about 600mW is used, for example. And it sets up so that the peak power reinforcement in the condensing spot 22 may become two or more 105 W/cm. By changing the cross section of the 2nd core 15 as mentioned above, the joint loss at the time of combining the optical coupling from which the spot size of guided wave light differs can be reduced.

[0032] Moreover, in case the condensing spot 22 is made displaced relatively to the bottom cladding layer 12 and the upper cladding layer 14 as described above, this passing speed is continuously changed by the table support mechanical component 32 and the lens support mechanical component 35. If it does in this way, as shown in drawing 6 (a) and (c), the refractive index of the 2nd core 15 can be changed continuously. If passing speed to the cladding layer of the condensing spot 22 is enlarged, specifically, the refractive index of the 2nd core 15 will become small. Therefore, it can become small continuously as the refractive index of the 2nd core 15 is almost equal to the refractive index of the 1st core 13 in respect of [17] connection with the 1st core 13 and separates from the connection side 17 in this case. Thus, since a refractive index will become small as the cross section becomes large if both the cross section of the 2nd core 15 and a refractive index are changed, propagation only of a certain specific mode can be attained, and it can raise the property of optical waveguide.

[0033] The optical coupling machine shown in drawing 2 above is completed. As shown above, the 2nd cross section and refractive index of a core 15 can be simply changed continuously only by changing the diameter of a condensing spot and passing speed of a laser beam 21. Therefore, core sizes differ, namely, the optical waveguides from which the spot size of guided wave light differs can be combined by low joint loss.

[0034] Moreover, generally the approach of irradiating a laser beam and forming optical waveguide into glass has a slow formation rate. However, since modification of spot size forms only a required part with laser among the cores which are optical waveguide and the other part is formed by the photolithography method for excelling in productivity as described above, productivity can be improved rather than the case where all optical waveguides are formed by laser.

[0035] Next, the optical coupling machine concerning the gestalt of operation of the 2nd of this invention and its manufacture approach are explained with reference to a drawing. The optical coupling machine concerning the gestalt of the 2nd operation is formed like the gestalt of the 1st operation between the 1st optical waveguide and the 2nd optical waveguide from which the spot size of guided wave light differs, and makes the optical waveguide of another side spread the light which carried out outgoing radiation from one optical waveguide. Moreover, in addition to the configuration of the optical coupling machine shown with the gestalt of the 1st operation, the optical coupling machine concerning the gestalt of the 2nd operation has the composition that the core bent on the way, as shown below.

[0036] Drawing 7 is the mimetic diagram showing the configuration of the optical coupling machine concerning the gestalt of the 2nd operation. In addition, drawing 7 (a) is a sectional view at the time of cutting in respect of being perpendicular to the substrate of an optical coupling machine including the propagation shaft of the propagation path (optical waveguide) of light, and drawing 7 (b) is a sectional view at the time of cutting in respect of being parallel to the substrate of an optical coupling machine. Moreover, drawing 7 (c) is the C-C' view Fig. of drawing 7 (b).

[0037] this optical coupling machine -- a substrate 11, the bottom cladding layer 12, the 1st core 13, the upper cladding layer 14, and the 2nd core 16 -- since -- it is constituted and is the almost same configuration as the photosynthesis machine shown with the gestalt of the 1st operation. However, the optical waveguide formed from the 1st core 13 and 2nd core 16 has bent in respect of [17] those connection. That is, to the 1st core 13 being formed in parallel with the front face of a substrate 11, the 2nd core 16 is formed so that it may have a certain include angle to the front face of a substrate 11.

[0038] Next, the manufacture approach of the optical coupling machine which are the above configurations is explained. It is the same as that of the gestalt of the 1st operation till the place which forms the bottom cladding layer 12 on introduction and a substrate 11, forms the 1st core 13 on the bottom cladding layer 12, and forms the upper cladding layer 14.

[0039] The condensing spot 22 is made displaced relatively to the bottom cladding layer 12 and the upper cladding layer 14 after formation of the upper cladding layer 14, using the laser radiation equipment shown in drawing 4 like the gestalt of the 1st operation, and changing the diameter of a condensing spot continuously, in order to form the 2nd core 16. Thereby, the locus part (a part of upper cladding layer 14) of the condensing spot 22 has a refractive index higher than a perimeter, and can form the 2nd core 16 from which the cross section changed continuously. Moreover, in case the condensing spot 22 is moved, by the table support mechanical component 32 and the lens support mechanical component 35, at least one of a lens 34, and the bottom cladding layers 12 and the upper cladding layers 14 is moved, and the distance of a lens 34 and an optical coupling machine front face is changed. The 1st core 13 and 2nd core 16 are connected in the bent form by this. In addition, the pulse width of the laser beam 21 to be used, output power, etc. are substantially [as the gestalt of the 1st operation] the same.

[0040] As furthermore described above, the refractive index of the 2nd core 16 can be changed with the passing speed of the condensing spot 22. In order to use this, the passing speed of the condensing spot 22 to the bottom cladding layer 12 and the upper cladding layer 14 is changed by the table support mechanical component 32 and the lens support mechanical component 35 of laser radiation equipment. It is made for the refractive-index difference of a core and a clad to become large by this. If it does in this way, light can close, eye ** can be strengthened, it can make it sudden to bend [core / 1st core 13 and / 16 / 2nd], and an optical coupling machine can be miniaturized.

[0041] An optical coupling machine is completed for the light shown in drawing 7 as mentioned above. As shown above, the optical waveguide which consists of the 1st core 13 and 2nd core 16 simply can be bent only by controlling the path and migration of the condensing spot 22. Moreover, the angle which the direction of outgoing radiation of the light from one optical waveguide and the direction of incidence of the light to the optical waveguide of another side make can set it as all the include angles of 0 - 180

degrees by changing how bending a core variously. Therefore, optical waveguides can be efficiently combined at various include angles by the small propagation loss, and the mounting cost of an optical device which has optical waveguide can be reduced.
[0042] Moreover, also in the gestalt of the 2nd operation, since modification of spot size forms only a required part with laser among the cores which are optical waveguide and the other part is formed by the photolithography method for excelling in productivity as described above, productivity can be improved rather than the case where all optical waveguides are formed by laser.
[0043] In addition, you may make it change by the approach except changing passing speed [as opposed to the clad of the diameter of a condensing spot, or the condensing spot 22 for the core size shown with the gestalt of the 1st and the 2nd operation, or the refractive index of a core]. For example, a diaphragm etc. may be established between the laser oscillation machine 33 of laser radiation equipment, and a lens 34, and the exposure power (the amount of energy) of a laser beam 21 may be changed. If the exposure power of a laser beam 21 is changed, as shown in drawing 5 (a) and (b), core size of the 2nd core 15 can be enlarged with the increment in exposure power. Moreover, the refractive index of a core may be changed by controlling the laser oscillation machine 33 and changing the count of an exposure of a laser beam 21. If the count of an exposure of a laser beam 21 is changed, as shown in drawing 6 (b) and (c), a refractive index can be reduced with reduction of the count of an exposure.
[0044] Furthermore, in order to change core size, the count of an exposure of the passing speed of the condensing spot 22 or a laser beam 21 may be changed. Moreover, in order to change the refractive index of a core, the exposure power of a laser beam 21 may be changed. Moreover, the above-mentioned approaches (passing speed of exposure power change of a laser beam 21, the diameter change of a condensing spot, and a condensing spot, count change of an exposure of a laser beam 21, etc.) may be combined and used. Moreover, as a means to change the path of the condensing spot 22 shown with the gestalt of the 1st and the 2nd operation, instead of changing the configuration of a lens 34, two or more lenses may be combined like the zoom lens of a single-lens reflex camera, and the distance between them may be changed.
[0045] Moreover, the 1st core 13 shown with the gestalt of the 2nd operation and the 2nd core 16 can also connect the 1st core 13 and 2nd core 16 by the smooth curve by controlling migration of the above-mentioned condensing spot 22, although it connects in the bent form. Thus, if optical waveguide is formed smoothly, a propagation loss can be reduced more.
[0046] The substrate 11 shown with the gestalt of the 1st and the 2nd operation, the bottom cladding layer 12, and the upper cladding layer 14 of either oxide glass, nitride glass, halogenation glass, sulfide glass and chalcogenide glass may be good, and may be those mixture. In addition, since it is hard to be influenced by the electric field of guided wave light when a substrate 11 is quartz (SiO2) glass etc., the bottom cladding layer 12 is omissible. Moreover, if a substrate 11 is used as a transparence substrate like a glass substrate, the laser beam 21 of ** which forms the 2nd core 15 as described above can be irradiated from a substrate 11 side.
[0047] moreover, the bottom cladding layer 12 shown with the gestalt of the 1st and the 2nd operation, the glass membrane used as the 1st core 13, and the upper cladding layer 14 -- chemical vapor deposition (CVD) -- law -- it may be formed by the approach of an except. for example, flame deposition (FHD) -- any of law, a spatter, and a spin coat method -- even when -- it may be good and such suitable combination is sufficient.

[Translation done.]

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damages caused by the use of this translation.

1.This document has been translated by computer. So the translation may not reflect the original precisely.
2.**** shows the word which can not be translated.
3.In the drawings, any words are not translated.

DESCRIPTION OF DRAWINGS

[Brief Description of the Drawings]
[Drawing 1] It is the mimetic diagram showing the condition of having connected the optical coupling machine applied to the gestalt of operation between two optical waveguides.
[Drawing 2] It is the mimetic diagram showing the configuration of the optical coupling machine concerning the gestalt of the 1st operation.
[Drawing 3] It is drawing showing the production process of the optical coupling machine shown in drawing 1 .
[Drawing 4] It is the mimetic diagram showing the configuration of the laser radiation equipment which irradiates laser in an optical coupling vessel.
[Drawing 5] They are the diameter of a condensing spot of laser, exposure power, and drawing showing change of core size.
[Drawing 6] They are the passing speed of laser, a count of an exposure, and drawing showing change of the refractive index of a core.
[Drawing 7] It is the mimetic diagram showing that of the optical coupling machine concerning the gestalt of the 2nd operation.
[Description of Notations]
11 Substrate
12 Bottom Cladding Layer
13 1st Core
14 Upper Cladding Layer
15 2nd Core
16 2nd Core
17 Connection Side
21 Laser Beam
22 Condensing Spot
31 Table
32 Table Support Mechanical Component
33 Laser Oscillation Machine
34 Lens
35 Lens Support Mechanical Component
36 Tube

[Translation done.]

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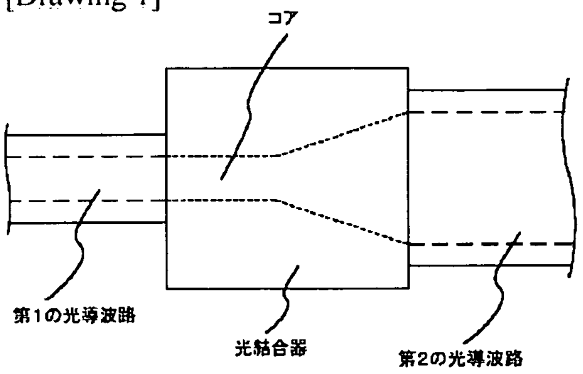
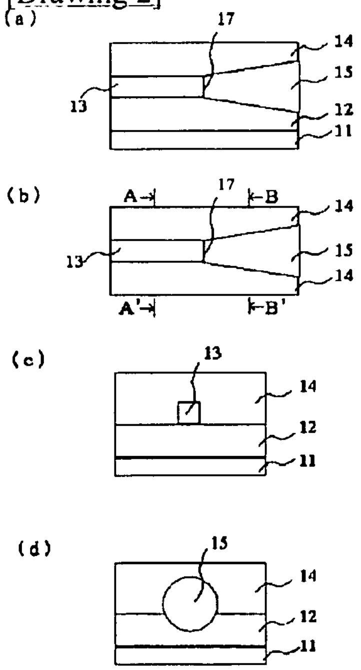
DRAWINGS

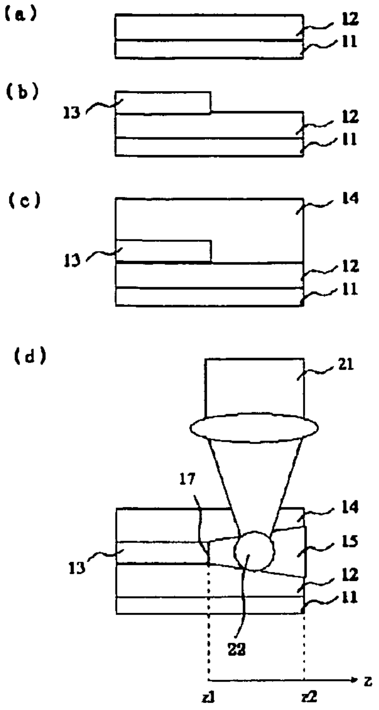
[Drawing 1]



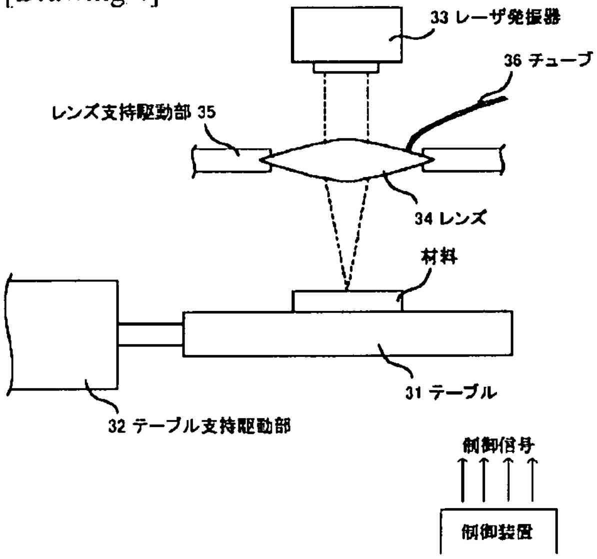
[Drawing 2]



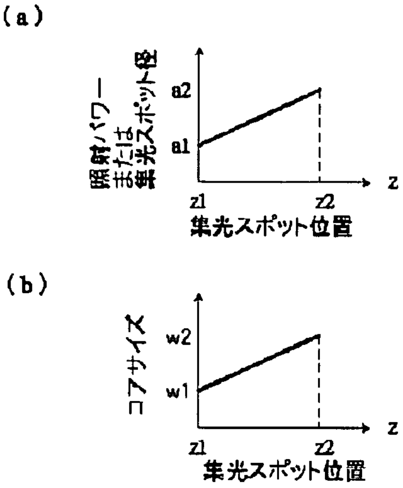
[Drawing 3]



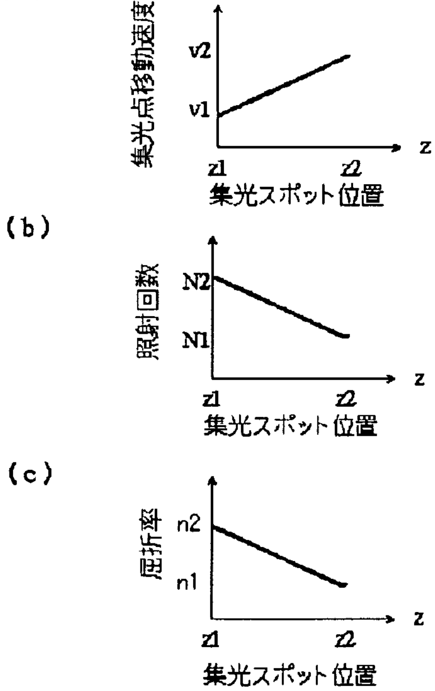
[Drawing 4]



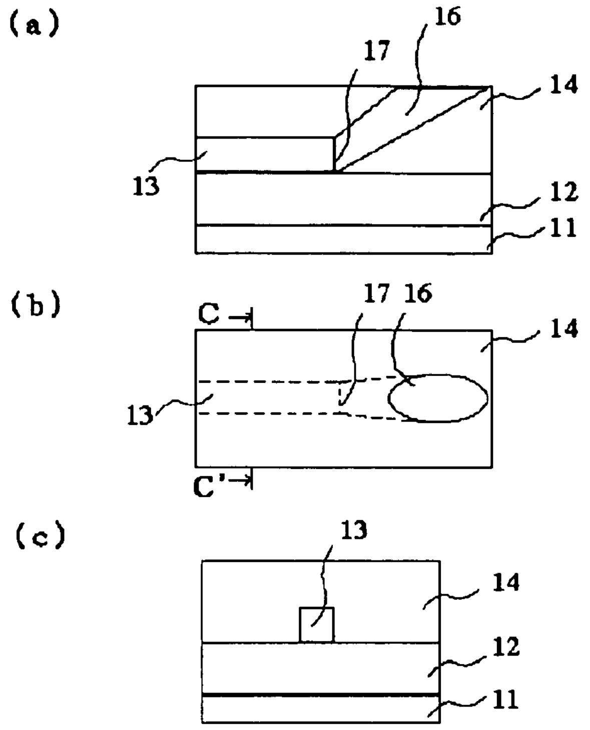
[Drawing 5]



[Drawing 6]



[Drawing 7]



[Translation done.]